

A. Measurement

1. Which of the following values has three significant figures?

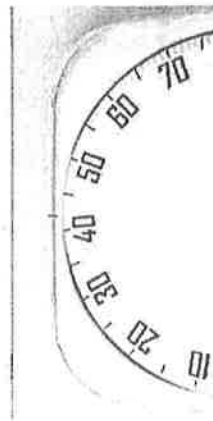
- A. 23.05 mL
- B. 2.350 mL
- C. 2.035 mL
- D. 0.235 mL

2. The length of a desk is measured to be $76.4 \text{ cm} \pm 0.05 \text{ cm}$. What is the absolute error of this measurement?

- A. 0.5 mm
- B. 5%
- C. 0.06%
- D. 0.07%

3. A person stands on a scale and measures their mass in kilograms as shown to the right. What is the relative error of this measurement?

- A. 0.011%
- B. 0.024%
- C. 1.2%
- D. 2.4%



4. Complete the following addition of measurements: $7.16 \text{ kg} + 0.735 \text{ kg}$

- A. 7.895 kg
- B. 7.89 kg
- C. 7.90 kg
- D. 7.9 kg

5. Complete the following multiplication of measurements: $45.2 \text{ m} \times 200 \text{ m}$

- A. $9.040 \times 10^3 \text{ m}^2$
- B. $9.04 \times 10^3 \text{ m}^2$
- C. $9.0 \times 10^3 \text{ m}^2$
- D. $9 \times 10^3 \text{ m}^2$

6. The diameter of a regulation basketball is quoted as $23.7 \text{ cm} \pm 2\%$. What is the smallest possible diameter for a regulation basketball?

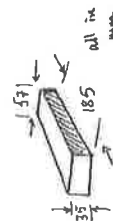
- A. 23.22 cm
- B. 23.2 cm
- C. 23.5 cm
- D. 21.7 cm

7. A beaker filled with fluid has a mass of 145.5 g. When emptied, the beaker has a mass of 89.4 g. What, therefore, was the mass of the fluid?

- A. 56.10 g
- B. 56.1 g
- C. 56 g
- D. 60 g

8. A rectangular solid block has dimensions $35 \text{ mm} \times 57 \text{ mm} \times 185 \text{ mm}$. If its mass is 54.32 g, what is the density of this material in g/cm^3 ? (Density = Mass/Volume)

- A. 0.1471 g/cm^3
- B. 0.147 g/cm^3
- C. 0.15 g/cm^3
- D. 0.0015 g/cm^3

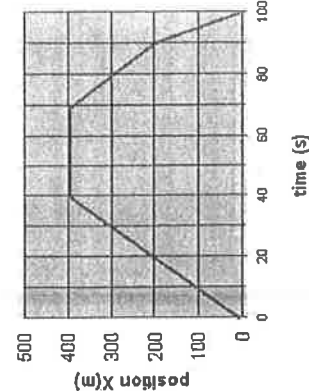


B. Distance, Speed, Acceleration

1. During an experiment, a student measures the energy of an object to be 152 J. The expected theoretical value was 165 J. What is the percent error in this experiment?

- A. 8%
- B. 13%
- C. 87%
- D. 92%

Use the position vs. time graph on the right to answer questions 2–5.



2. What is the instantaneous speed at time 50 s?

- A. 0 m/s
- B. 8 m/s
- C. 200 m/s
- D. 400 m/s

3. What is the magnitude of the maximum velocity shown on the graph?

- A. 8 m/s
- B. 10 m/s
- C. 20 m/s
- D. 400 m/s

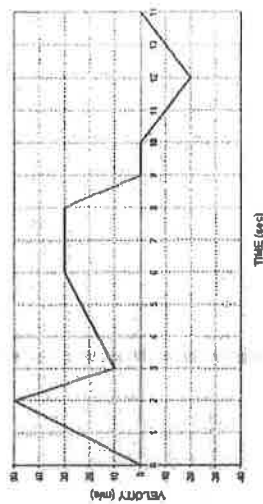
4. What is the average speed during the first 70 seconds of travel?

- A. 5.7 m/s
- B. 8.0 m/s
- C. 10 m/s
- D. 20 m/s

5. What is the total displacement of the object after 90 seconds?

- A. 0 m
- B. 200 m
- C. 400 m
- D. 600 m

Use the velocity vs. time graph on the right to answer questions 6–8.



6. In which time region does the object have the greatest acceleration?

- A. 0–2 seconds
- B. 2–3 seconds
- C. 3–6 seconds
- D. 6–8 seconds

7. What is the instantaneous velocity at time 7 seconds?

- A. 0 m/s
- B. 30 m/s forward
- C. 30 m/s backward
- D. not enough information

8. What distance does the object travel during the time interval 10 s – 14 s?

- A. 0 m
- B. 20 m
- C. 40 m
- D. 80 m

C. Kinematics of Uniform Acceleration

1. On wet pavement, the maximum deceleration for a car is about 4.4 m/s^2 . What distance is required to come to a complete stop from a speed of 120 km/h during a rain storm?

A. 130 m
B. 200 m
C. 310 m
D. 460 m

2. A bartender slings a drink across the bar top to a waiting customer. After a time of 1.45 s it comes to rest, sliding a complete distance of 3.50 m . What average (magnitude only) acceleration does the glass experience?

A. 0.83 m/s^2
B. 3.3 m/s^2
C. 4.6 m/s^2
D. 9.8 m/s^2



3. An Airbus 380 must reach an air speed of 280 km/h to take off. Leaving from rest, it takes about 12 seconds to reach this speed. What is the minimum runway length to do this?

A. 47 m
B. 233 m
C. 470 m
D. 540 m

4. An object at rest is dropped from a height of 550 m . After falling for 5.7 seconds , the object reaches its terminal velocity. What is its acceleration at this point?

A. 0 m/s^2
B. 4.9 m/s^2
C. 8.5 m/s^2
D. 9.8 m/s^2

5. An astronaut drops a hammer from a height of 1.2 m above the surface of an alien planet. If the time to fall this distance is 0.23 s , what is the value of " g " on this planet?

A. 2.3 m/s^2
B. 9.8 m/s^2
C. $10. \text{ m/s}^2$
D. 45 m/s^2

6. A feather falls more slowly than a penny when released from the same height. One could argue that this is because light objects "feel less gravity". What is(are) the true reason(s) for this noticeable effect?

A. The weight of the feather
B. The shape of the feather
C. The atmosphere
D. Both B and C.

7. The Fountain of Nations in Disney World shoots water to a maximum height of 46 m . What initial speed does the water have when it shoots out of the nozzle?

A. 9.8 m/s
B. 30 m/s
C. 60 m/s
D. 900 m/s

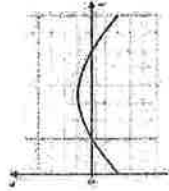
8. A bullet is fired upwards with a speed of 700 m/s . What maximum height will it reach?

A. 35 m
B. 25 km
C. 35 km
D. 100 km

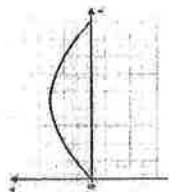
D. Graphing

Use the following position vs. time graphs to answer questions 1 and 2.

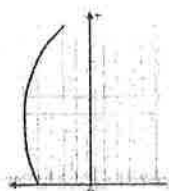
A.



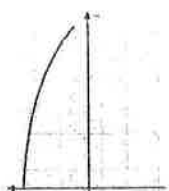
B.



C.



D.



1. Which one of the D vs. T shows the greatest displacement?

A. B. C. D.

2. Which of the D vs. T graphs above matches the V vs. T graph shown here?

A. B. C. D.



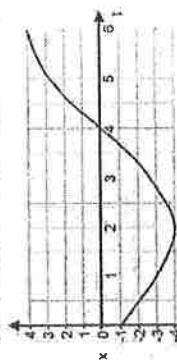
3. What is the magnitude of the average velocity of the object over the entire graph?

A. 0.67 m/s
B. 0.83 m/s
C. 1.3 m/s
D. 2.0 m/s

4. What, approximately, is the instantaneous velocity at time 4.0 s ?

A. 0 m/s B. 1 m/s C. 3 m/s D. 4 m/s

Use the position (m) v. time (s) graph below to answer questions 3 & 4



5. What is the instantaneous acceleration at a time 2.0 s ?

A. 0 m/s^2 C. 4 m/s^2
B. 2 m/s^2 D. 8 m/s^2

6. What is the total displacement of the graph?

A. 2 m C. 14 m
B. 6 m D. 22 m

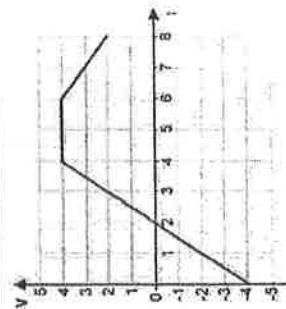
7. At what time(s), if any, on the graph is the object at rest?

A. 0 s C. $4-6 \text{ s}$
B. 2 s D. it is always moving

8. At what time does the object change direction?

A. 0 s C. $4-6 \text{ s}$
B. 2 s D. it is always moving in one direction

Use the velocity (m/s) v. time (s) graph below to answer questions 5-8



E. Dynamics

1. Which of the following is NOT one of the fundamental forces that govern all motion in the universe?

- A. Strong nuclear force
- B. Weak nuclear force
- C. Magnetic force
- D. Electric force

2. The Earth has a roughly circular orbit around the Sun, moving at roughly a constant speed of 30,000 m/s. Which of the following statements is NOT true?

- A. The velocity is constantly changing
- B. It is gravitationally attracted to the Sun
- C. There is no net force on the Earth as it moves
- D. The forces on the Earth as it orbits are unbalanced

3. A car is travelling along a perfectly level highway at a constant velocity of 100 km/h [E]. Which of the following statements is true?

- A. No net force acts on the car
- B. There is a net force acting on the car
- C. There are no forces acting on the car
- D. The car is accelerating due to the force of the engine

4. An object of mass m has an acceleration a when a force F is applied. What is the acceleration when the same force F is applied to a mass $4m$?

- A. $\frac{1}{4}a$
- B. $\frac{1}{2}a$
- C. $2a$
- D. $4a$

5. Which of the following masses is attracted to the Earth with a pull of 15 N?

- A. 0.0015 kg
- B. 0.15 kg
- C. 0.65 kg
- D. 1.5 kg

6. A person with a weight of 520 N on Earth has a weight of 1250 N on an alien planet. What is the value of "g" for that planet?

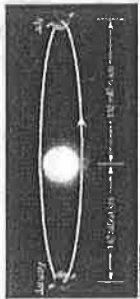
- A. 0.042 m/s^2
- B. 0.42 m/s^2
- C. 2.4 m/s^2
- D. 24 m/s^2

7. An 1.5 kg book is at rest on a desk top. What is the normal force of the desk on the book?

- A. 0 N
- B. 1.5 N
- C. 9.8 N
- D. 15 N

8. A 2500 kg car accelerates along a horizontal road at 3.5 m/s^2 . What is the net force acting on the car?

- A. $1.4 \times 10^3 \text{ N}$
- B. 710 N
- C. 8800 N
- D. 25 000 N



F. Friction

1. A 10 kg box is at rest on top of a desk. If a 35 N force is exerted downward on the box, what is the normal force on the box?

- A. 0 N
- B. 63 N
- C. 98 N
- D. 130 N

2. A 3.5 kg box is pushed across a level surface with a friction coefficient of $\mu = 0.39$. What force of friction acts on the box?

- A. 1.4 N
- B. 3.5 N
- C. 9.8 N
- D. 13 N

3. A 4.5 kg object is at rest on a table with $\mu_s = 0.56$ $\mu_k = 0.46$. What minimum force is required to get the object to start moving?

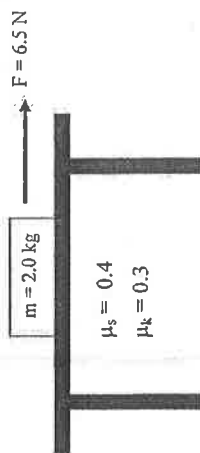
- A. 2.1 N
- B. 2.5 N
- C. 21 N
- D. 25 N

4. A 4.5 kg object is at rest on a table with $\mu_s = 0.56$ $\mu_k = 0.46$. A force is applied such that the object just begins to move. If that same force is maintained, at what rate will the object accelerate?

- A. 0 m/s^2
- B. $\frac{0.36}{4.5} \text{ m/s}^2$
- C. 4.4 m/s^2
- D. 5.5 m/s^2

5. A 2.0 kg block is at rest on a table. At what rate will it accelerate when a force of 6.5 N is exerted on the block?

- A. 0 m/s^2
- B. 0.31 m/s^2
- C. 0.62 m/s^2
- D. 0.67 m/s^2



6. A 1500 kg car drives along a level road at a constant speed. If the engine provides an average force of 2700 N, what is the force of friction acting on the car?

- A. 0 N
- B. 500 N
- C. 1200 N
- D. 2700 N

7. A 2500 kg car is parked in your spot at work. If the coefficient of static friction for the tires and road is $\mu = 0.45$, what force would have to be exerted to drag the car out of the space without releasing the brake?

- A. 0 N
- B. 1100 N
- C. 11 000 N
- D. 25 000 N

8. A 75 kg biker traveling 35 km/h on a level road stops pedaling and decelerates uniformly to a stop in 42 seconds. What is the coefficient of rolling friction acting between the bike and road?

- A. 0.024
- B. 0.085
- C. 0.23
- D. 0.45

G. Hooke's Law & Sundries

1. A 200 g mass is hung on the end of an elastic band with a spring constant of 45 N/m. How much does it stretch from the rest position?
A. 4.4 cm B. 44 cm C. 9.0 cm D. 88 cm
2. A mass of 35 kg causes a spring to compress by 3.5 cm. What is the spring constant for this material?
A. 10 N/m B. 98 N/m C. 1000 N/m D. 9800 N/m
3. A wooden meter stick is calibrated so that 15 N causes a deflection of 2.5 cm. What mass will cause a deflection of 16.2 cm?
A. 4.4 kg B. 8.9 kg C. 9.9 kg D. 97 kg

4. An airplane is accelerating uniformly through the air along a perfectly horizontal path. Which of the following free body diagrams best shows the forces acting on the plane?



5. The Sun pulls on the Earth with a gravitational force of 1.8×10^{24} N. What gravitational force does the Earth exert on the Sun?

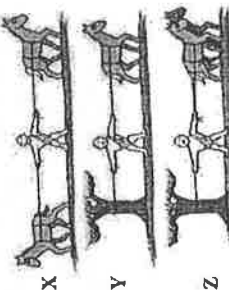
- A. 0 N B. 9.8 N C. 1.8×10^{24} N D. 6.0×10^{24} N

6. During a boxing match, where should a boxer hit his opponent to apply more force than his opponent applies to him?

- A. head B. stomach C. kidney D. Not possible

7. A 7.8 kg gun causes a 25 g bullet to accelerate in a forward direction at 7.0×10^5 m/s². At what rate does the gun accelerate?

- A. 1145 m/s² B. 2.2×10^3 m/s² C. 9.0×10^3 m/s² D. 7.0×10^5 m/s²



8. Which of the following correctly ranks the three strong men shown in the illustration to the right?

	1 st	2 nd	3 rd
A.	X	Z	Y
B.	Z	Y	X
C.	Z	X, Y	-
D.	X	Y, Z	-

H. Universal Gravitation

1. At what distance (in Earth radii) above the Earth's surface does gravity no longer exist?

- A. R_E
B. $2R_E$
C. $4R_E$
D. ∞

2. What is the gravitational force of attraction does your left eye exert on your right eye? $M_{\text{eye}} = 46$ grams, $d = 6.0$ cm

- A. 2.4×10^{12} N
B. 3.9×10^{11} N
C. 2.4×10^{10} N
D. 3.9×10^9 N

3. At what distance of separation would two 10 kg masses exert a gravitational force of 1.0 N on one another?

- A. 6.7×10^{11} m
B. 6.7×10^9 m
C. 8.2×10^2 m
D. 8.2×10^3 m

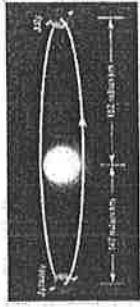
4. An object of mass m experiences an acceleration g when at a distance R from a planet. What is the acceleration when the object is moved to a distance $\frac{1}{2}R$?

- A. $\frac{1}{4}g$
B. $\frac{1}{2}g$
C. $2g$
D. $4g$

5. What pulls on your body more; the Earth or the Sun?

- Distance between you and Earth = $R_E = 6380$ km
Distance between you and Sun = 1.5×10^{11} m
Mass of Earth = 5.98×10^{24} kg
Mass of Sun = 1.99×10^{30} kg
Mass of average person = 70 kg

- A. Sun
B. Earth
C. They are equal
D. Not possible



6. Mars has a radius of 3397 km. An astronaut experimentally determines the gravitational acceleration to be 3.72 m/s². What is the mass of mars?

- A. 6.44×10^{23} kg B. 6.44×10^{17} kg C. 1.89×10^{17} kg D. 4.38×10^{12} kg

7. A spaceship of mass m is a distance R away from a giant star of mass M . Suddenly, the star collapses to form a new star with only half the radius it had before. What will happen to the force of gravity felt by the spaceship?

- A. It will half B. It will double C. It will quadruple D. No change

8. A planet has mass M , and radius R . Suspended slightly above the surface is an object, mass m . When determining the free fall acceleration of the dropped object, m , which variable is irrelevant?

- A. G B. M C. m D. R

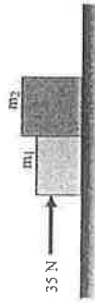
I. Multi-body Problems, Momentum & Impulse

- Two masses are suspended on opposite sides of a frictionless pulley, as shown. The cube has a mass of 3.5 kg, and the sphere is 2.5 kg. What is the acceleration of the system when released?

- 1.63 m/s²
- 2.80 m/s²
- 3.92 m/s²
- 9.81 m/s²

- Two boxes, mass 4.0 kg and 5.0 kg are set next to one another on a frictionless surface. The first box is pushed with a force of 35 N. What normal forces does the second box exert on the first box during this process?

- 0 N
- 16 N
- 19 N
- 35 N



- The average speed of the Earth's orbit is 30,000 m/s. If the mass of the Earth is 5.98×10^{24} kg, what is Earth's orbital momentum?

- 0 kg m/s
- 5.0×10^{28} kg m/s
- 1.8×10^{29} kg m/s
- 6.5×10^{29} kg m/s

- What speed would a 75 kg bike and rider have to reach to match the momentum of a 2500 kg car travelling 50 km/h?

- 50 km/h
- 130 km/h
- 460 km/h
- 1700 km/h

- A 95 kg bad guy is running towards a gun-shooting "good guy" with a speed of 4.0 m/s. How many 12 gram bullets travelling at 700 m/s are required to "eliminate" the bad guy's momentum?

- 9
- 40
- 41
- 340

- In the movie Spiderman II, the hero stops a 1.0×10^7 kg train with speed of 128 km/h by exerting a force for 35 seconds (although it seems like forever). What average force does he exert during this time?

- 2.8×10^6 N
- 1.0×10^7 N
- 3.7×10^7 N
- 1.0×10^9 N

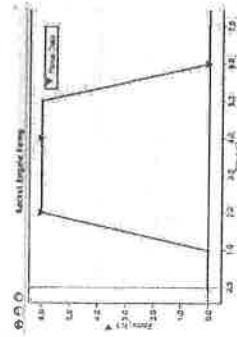


- A 45 gram golf ball hits the ground with a speed of 1.0 m/s and rebounds upward with a speed of 0.75 m/s. What is the impulse on the ball? (Impulse = change in momentum)

- 0 kg m/s
- 1.1×10^{-2} kg m/s
- 3.4×10^{-2} kg m/s
- 7.9×10^{-2} kg m/s

- The graph to the right shows the impulse of a rocket engine over time. What total impulse is delivered to the rocket? (Use units $F \Delta t = N \cdot s$)

- 6 N's
- 18 N's
- 24 N's
- 36 N's



J. Momentum: Impulse and Collisions

- What is the approximate momentum of an adult while walking?

- 10 kg m/s
- 100 kg m/s
- 1,000 kg m/s
- 10,000 kg m/s

- A bat delivers 28 N's of impulse to a 250 g ball, initial at rest. What is the final speed of the ball?

- 7.0 m/s
- 38 m/s
- 65 m/s
- 110 m/s



- During an accident, a car rapidly changes speed from 40 m/s to 0 m/s. Which of the following would reduce the forces experienced by the passengers?

- Increasing the acceleration
- Increasing the impulse
- Increasing the time length of the collision
- Decreasing the time length of the collision

- A red ball of mass 4.0 kg rolling at 3.5 m/s collides with a blue stationary ball of mass 8.0 kg. The red ball experiences an impulse of -12 N's. What impulse does the blue ball experience?

- 12 N's
- 14 N's
- 24 N's
- 28 N's

- A 90 kg astronaut, initially at rest, throws a space wrench with a speed of 13.0 m/s. As a result, the astronaut coasts off in the other direction with a speed of 0.50 m/s. What is the mass of the wrench?

- 0.29 kg
- 3.5 kg
- 6.9 kg
- 14 kg



- In the movie Lord of the Rings, Legolas (mass 35 kg) can fire arrows with such great speed that massive orcs are stopped dead in their tracks. If we estimate his arrows to have a mass of 250 g and a necessary speed of 2400 m/s, what recoil speed is experienced by Legolas from firing a single arrow? Assume his initial speed is zero.

- 17 m/s
- 69 m/s
- 340 m/s
- 17,000 m/s


- A 12.0 kg box with speed 4.5 m/s collides with a stationary 5.0 kg box. The 12.0 kg box speed is reduced to 2.5 m/s. If they do not stick together, what is the final speed of the 5.0 kg box?

- 3.2 m/s
- 4.8 m/s
- 6.4 m/s
- 11 m/s

- A truck travelling 15 km/h coasts into a stationary car and they lock together. The truck weighs four times more than the car. What is the final speed of the two vehicles?

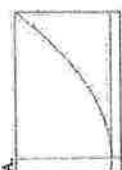
- 0.86 m/s
- 3.3 m/s
- 4.2 m/s
- 12 m/s

K. Work & Energy

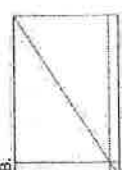
- What net work is required for a 5.0 kg object to move a horizontal distance of 35 m at a constant speed?
 - 0 J
 - 49 J
 - 180 J
 - 1700 J
 - What minimum work is required to lift a 8.5 kg object a vertical distance of 15 m?
 - 0 J
 - 83 J
 - 130 J
 - 1200 J
- 
- A net work of -2300 J is applied to a 12 kg object traveling 25 m/s [East]. What is the object's final speed?
 - 16 m/s [East]
 - 16 m/s [West]
 - 32 m/s [East]
 - 32 m/s [West]
 - An 2.0 kg ball, initially at rest, falls from a height of 6.0 m above the ground. At what point during the fall does it have a kinetic energy of 130 J?
 - 1.2 m
 - 3.0 m
 - 4.8 m
 - not possible
 - During a demonstration, a bowling ball pendulum is pulled backward and then released from rest. At its lowest point, it is at a height of 0.35 m above the ground and has a speed of 6.0 m/s. What maximum height does it attain on the other side of its swing?
 - 1.5 m
 - 1.8 m
 - 2.2 m
 - need more information
 - A 2.5 kg rock is dropped from a 350 m cliff. It hits the ground with a speed of 60 m/s. What percent of its mechanical energy was lost to air resistance?
 - 10 %
 - 48 %
 - 52 %
 - 90 %
 - A motor uses 5500 J to lift a 35 kg object a vertical distance of 12 m. What is the efficiency of the motor?
 - 0.08
 - 0.25
 - 0.75
 - 0.92
 - An object thrown in an arc across a room. Assuming no air drag, which of the following statements is true?
 - Its kinetic energy is constant
 - The mechanical energy decreases as it rises
 - Its potential energy could be less than zero
 - The kinetic energy is momentarily zero at the top of the arc

L. Proportionalities


- In Newton's Second Law, what is the relationship between mass and acceleration?
 - Linear
 - Square
 - Inverse
 - Inverse Square
- In a graph of momentum versus speed for an object with constant mass, what shape would the graph take?
 - Linear
 - Square
 - Inverse
 - Inverse Square
- Which of the following could be a graph showing the relationship between distance and time for an object in free fall?



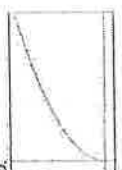
A.




B.




C.



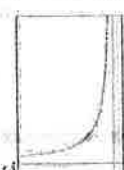
D.
- Which of the following could be a graph showing the strength of gravitational attracting between two metal spheres as the mass of one of the spheres is increased?



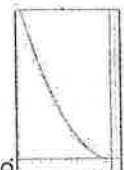
A.




B.




C.




D.
- Which of the following graphs shows the relationship between the mass of an object and its speed while the kinetic energy remains constant?




A.



B.



C.

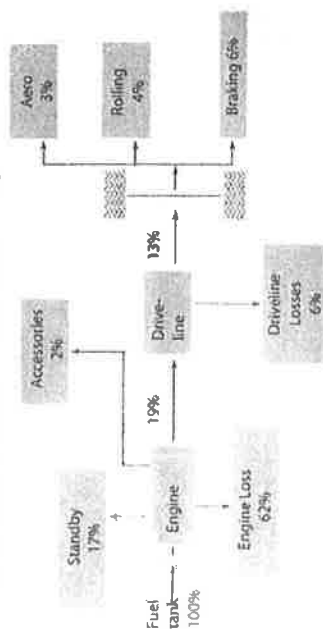


D.
- In a Hooke's Law experiment, a student makes a graph of Force vs. Displacement. What is the shape of the resulting graph, and what is the value of the slope?
 - linear, k
 - linear, 1/k
 - inverse, k
 - inverse, 1/k
- In acoustics (the study of sound) Intensity (loudness) is inversely proportional to the square of the distance from the source. If the intensity is I at a distance d , what is the intensity at a distance $4d$?
 - $1/16 I$
 - $1/8 I$
 - $1/4 I$
 - $1/2 I$
- In the expression "Distance makes the heart grow fonder" how are distance and love related?
 - Linear
 - Square
 - Inverse
 - Inverse Square

M. Power & Efficiency

1. A motor does 3.2×10^5 J of work in 2.0 hours. What is the minimum power rating of this engine?
A. 16 W B. 44 W C. 89 W D. 160,000 W
2. How many kilowatt hours does a 800W refrigerator use in a 30 day month?
A. 24 kWh B. 27 kWh C. 580 kWh D. 24,000 kWh
3. BC Hydro charges \$5.91 per kWh. How long does it take a 100 W light bulb to use up \$1.00 of energy?
A. 0.59 h B. 1.7 h C. 5.9 h D. 17 h
4. A small bag of Mrs. Vickies Sweet Chili and Sour Cream chips contains 230 Calories. To what maximum height could a 70 kg person climb with this amount of energy? (1000 calories = 1 Calorie = 4.19 kJ)
A. 1.4 m B. 14 m C. 140 m D. 1400 m
5. A 2500 kg sports car goes from 0 km/h to 100 km/h in just 13 seconds. What minimum power does this require?
A. 9.6 kW B. 74 kW C. 960 kW D. 92,000 kW
6. Hydroelectric plants can convert the energy of 1.0 kg of water falling 10m into approximately 75 J of electrical energy. What is the efficiency of this process?
A. 48 % B. 75 % C. 77 % D. 98 %

Use the "Energy Use In A Car" diagram below to answer questions 7 & 8



7. How efficient is a car at delivering energy to the tires of a car?
A. 4 % B. 13 % C. 19 % D. 38 %
8. Of the energy that makes it to the tires in a car, what portion is lost to braking?
A. 4 % B. 6 % C. 13 % D. 46 %

N. Thermodynamics

1. Which of the following quantities is most related to temperature?
A. Kinetic Energy
B. Acceleration
C. Force
D. Mass
2. Which of the following states of matter does NOT expand as its temperature increases?
A. Solid
B. Liquid
C. Gas
D. None of these
3. How many states of matter are there in the universe?
A. 1
B. 2
C. 3
D. 4
4. What is thermal energy?
A. The sum of all the kinetic energy of the particles in a body
B. The average kinetic energy of the particles in a body
C. The average temperature of the particles in a body
D. The heat exchanged between two bodies
5. The boiling point of Neon is -246°C . Why does Neon vaporize at such a low temperature?
A. It is a diatomic molecule.
B. It is a very light molecule.
C. It has a small specific heat capacity
D. It has a low intermolecular attraction
6. Cooling a 500 g piece of glass by 35°C releases 7820 J of heat. What is the specific heat capacity of glass?
A. $85 \text{ J/kg}^\circ\text{C}$
B. $740 \text{ J/kg}^\circ\text{C}$
C. $7800 \text{ J/kg}^\circ\text{C}$
D. $8.2 \times 10^7 \text{ J/kg}^\circ\text{C}$
7. According to Wikipedia.org there is $1.3 \times 10^6 \text{ km}^3$ of salt water in the ocean with an average temperature of around 4°C . How much energy would be required to raise the average temperature of the oceans by 1°C ?
Density of salt water $1.025 \times 10^3 \text{ kg/m}^3$
Specific Heat of Ocean Water $3980 \text{ J/kg}^\circ\text{C}$
A. $5 \times 10^{12} \text{ J}$
B. $2 \times 10^{13} \text{ J}$
C. $5 \times 10^{14} \text{ J}$
D. $6 \times 10^{14} \text{ J}$
8. Equal masses of two liquids are mixed together. Liquid A starts at 50°C and Liquid B starts at 80°C . When they are finished mixing, the final temperature is 72°C . Which of the following statements is true?
A. Liquid A has a higher heat capacity than Liquid B
B. Liquid B has a higher heat capacity than Liquid A
C. Liquid A has a higher latent heat than Liquid B
D. Liquid B has a higher latent heat than Liquid A

O. Special Relativity

1. Einstein on a bicycle is directly approaching a stationary observer at speed v when he turns on his headlight. At what speed does the light approach the observer?

A. c
B. v
C. $c - v$
D. $c + v$

2. According to the Special Theory of Relativity, which of the following quantities is the same from any point of observation?

A. time
B. mass
C. length
D. speed of light

3. At what speed could a passing meter stick appear to be 50 cm in length?

A. $0.5c$
B. $0.74c$
C. $0.87c$
D. $2.0c$

4. What did the Michelson-Morley Experiment attempt to measure?

A. The speed of light in a vacuum.
B. The average Earth-Sun distance.
C. The position of the centre of the universe.
D. The "ether wind" caused by Earth's motion.

5. Two gangsters have a disagreement. After some time, they give one another some respect, and decide to go their separate ways. Thug A walks 2.0 m/s [East] with respect to the ground. Thugs B walks away at 1.0 m/s [West] with respect to the ground. Looking over his shoulder (just to be sure!) Thug B watches Thug A. What speed does Thug A have with respect to Thug B?

A. 1.0 m/s [East]
B. 3.0 m/s [East]
C. 1.0 m/s [West]
D. 3.0 m/s [West]
E. Depends who gets more respect

6. What is the gamma value associated with a relative speed of $2.0 \times 10^8 \text{ m/s}$?

A. 0.75
B. 1.10
C. 1.34
D. 1.50

7. At what speed does a proton appear to weigh as much as two protons?

A. $0.5c$ B. $0.87c$ C. $0.93c$ D. c

8. A person drops a ball and records the time t for the ball to hit the ground. An observer moving by very quickly records the same event as taking a time t' . Which of the following statements is true?

A. $t > t'$
B. $t < t'$
C. $t = t'$
D. need more information

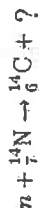


P. Nuclear Physics

1. What particle is released when Ge-75 transmutes into Ge-75?

A. Proton B. Beta C. Neutron D. Alpha

2. The following reaction is from the Radiocarbon Dating page of Wikipedia.org. On the left, a neutron (created by cosmic rays bombarding the atmosphere) has collided with atmospheric Nitrogen. What is the missing product on the right side of this natural transmutation?



A. proton B. alpha C. electron D. neutron

3. A sample of the medical isotope Iodine-131 is reduced to $1/16^{\text{th}}$ its original amount after a month. What is the approximate half life of this isotope?

A. 2 days B. 4 days C. 8 days D. 16 days

4. Which of the following elements is the most stable "end product" of both the fission and fusion process?

A. Lead B. Uranium C. Iron D. Carbon

5. Which of the following could be a fusion reaction?

A. ${}^{238}\text{Po} \rightarrow {}^{218}\text{Pb} + {}^4\text{He}$
B. ${}^2\text{H} + {}^3\text{H} \rightarrow {}^4\text{He} + n + \text{energy}$
C. ${}^{235}\text{U} + n \rightarrow {}^{141}\text{Ba} + {}^{92}\text{Kr} + 3n + \text{energy}$
D. ${}^{210}\text{Po} \rightarrow {}^{210}\text{Pb} + {}^4\text{He}$

6. A typical North American household uses 11,000 kWh of electricity each year. How much mass would have to be converted into energy to meet this need?

A. $1.2 \times 10^{13} \text{ kg}$ B. $4.4 \times 10^{-7} \text{ kg}$ C. $3.7 \times 10^{-3} \text{ kg}$ D. 132 kg

7. The "Little Boy" bomb dropped on Hiroshima was designed to release 50 terajoules ($\text{tera} = 10^{12}$) of stored uranium energy in 1.0 second. The CANDU Plant in Pickering Ontario uses the same fuel and has been releasing energy at a rate of $4.12 \times 10^6 \text{ J}$ each second since 1971. Which of the following statements is true?

	Most Powerful (W)	Most Energy Generated (J)
A.	Little Boy	Little Boy
B.	Little Boy	CANDU
C.	CANDU	Little Boy
D.	CANDU	CANDU

8. What process is the main source of energy for the Sun?

A. Alpha Decay
B. Beta Decay
C. Fission
D. Fusion

Q. Wave Mechanics I

1. The Earth completes 7 rotations on its axis every week. What is its period and frequency?

Period (s)	Frequency (Hz)
A. 24	4.2×10^{-2}
B. 24	1.2×10^{-3}
C. 86 400	4.2×10^{-2}
D. 86 400	1.2×10^{-3}

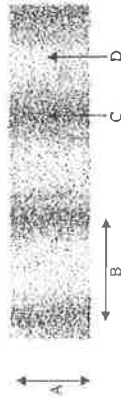
2. Tarzan, initially at rest, swings on a vine-pendulum to his beloved Jane at a point on the other side equal in height to his starting point. How long does this take, if the vine is 39 m long?

- A. 4.0 s
- B. 6.3 s
- C. 13 s
- D. 25 s

3. Which of the following statements about waves is false?

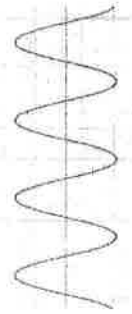
- A. Sound is a longitudinal wave
- B. Wave speed is determined by the medium
- C. Frequency of a wave is determined by the source
- D. None of these

4. In the diagram below, which arrow correctly shows a rarefaction?



5. What is the amplitude and wavelength of the graph shown?

	Amplitude	Wavelength
A.	3	2.5
B.	3	5
C.	6	2.5
D.	6	5



6. CBC Radio One broadcasts on 690 AM, which has a carrier frequency of 690 kHz. What is the wavelength of this signal?

- A. 0.0023 m
- B. 430 m
- C. 690 m
- D. 430,000 m

7. Humans can detect sounds with wavelengths as long as 17 m and as short as 1.7 cm. If the speed of sound in air is 343 m/s, what range of frequencies does this represent?

- A. $0.017 \rightarrow 17$ Hz
- B. $5 \rightarrow 500$ Hz
- C. $58 \rightarrow 5800$ Hz
- D. $20 \rightarrow 20,000$ Hz

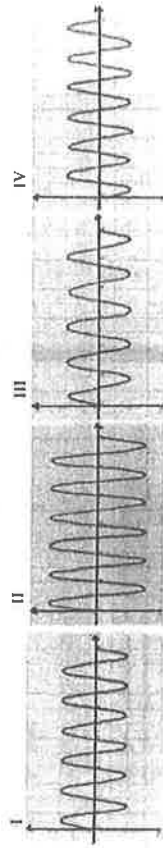
8. What effect is illustrated to the right?



- A. Diffraction
- B. Refraction
- C. Reflection
- D. Interference

R. Wave Mechanics II

Use the graphs below to answer questions 1 & 2



1. Which graphs would interfere and collapse on the x-axis?

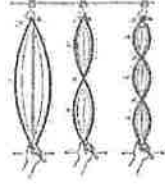
- A. I and III
- B. III and IV
- C. I and IV
- D. Both A and B

2. Which graphs would interfere to create a beat frequency?

- A. I and III
- B. I and III
- C. III and IV
- D. All of these

3. If the wavelength of the middle image is 1.0 m, what is the wavelength of the bottom image?

- A. 0.33 m
- B. 0.50 m
- C. 0.66 m
- D. 1.5 m



4. What causes the "ringing" effect of a wetted finger on a wine glass?

- A. Interference
- B. Resonance
- C. Standing waves
- D. Diffraction

5. What causes the bright/dark fringes seen in the image to the right?

- A. Interference
- B. Resonance
- C. Standing waves
- D. Diffraction

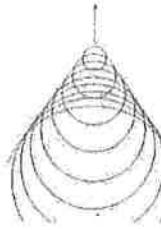


6. Two tuning forks, 440 Hz and 429 Hz, are struck simultaneously. What beat frequency does this produce?

- A. 11 Hz
- B. 29 Hz
- C. 40 Hz
- D. 869 Hz

7. The image to the right shows an object traveling through air. Which of the following is the best estimate of its speed?

- A. 100 m/s
- B. 200 m/s
- C. 300 m/s
- D. 400 m/s



8. Red light has a frequency of 4×10^{14} Hz and green light is 6×10^{14} Hz. At what speed and direction would you have to travel to cause a red light to appear green? ($c = 3.0 \times 10^8$ m/s)

Speed	Direction
A. 0.50 c	towards
B. 0.50 c	away
C. 0.67 c	towards
D. 0.67 c	away

S. Mirrors & Refraction

1. The image to the right shows a man standing in front of a concave mirror. At what distance d is he standing from the vertex of the mirror?



- A. $d > 2f$
 B. $d = 2f$
 C. $2f > d > f$
 D. $d < f$

2. An object is placed 15 cm away from a concave mirror with focal length 10 cm. Where does the image appear?

- A. 5 cm
 B. 10 cm
 C. 20 cm
 D. 30 cm

3. What speed does light have in a material with $n = 1.65$?

- A. 0.61 c
 B. 0.65 c
 C. 0.75 c
 D. 0.88 c

4. How much longer would it take for light to travel through 1.0 km of water than 1.0 km of air?

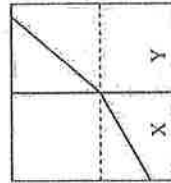
- A. 0 s
 B. 1.1×10^{-4} s
 C. 3.3×10^{-4} s
 D. 4.4×10^{-6} s

5. A ray with a 45° angle of incidence passes from air into crown glass and refracts at 28° . What is the index of refraction for crown glass?

- A. 1.33
 B. 1.40
 C. 1.51
 D. 1.65

6. The illustration to the right shows the path of a ray as it crosses a vertical boundary between two mediums, X and Y. The dotted line is normal to the interface boundary. Which of the following is true concerning wave speed and index of refraction?

Wave Speed	Index of Refraction
A. $X > Y$	$X > Y$
B. $X < Y$	$X < Y$
C. $X > Y$	$X < Y$
D. $X < Y$	$X > Y$



7. What is the critical angle for a glass/air interface where $n_{\text{glass}} = 1.41$ and $n_{\text{air}} = 1.00$?

- A. 35°
 B. 45°
 C. 49°
 D. 54°

8. The image to the right illustrates the mechanism behind mirages. What wave phenomena is responsible for this effect?

- A. Reflection
 B. Refraction
 C. Diffraction
 D. Interference

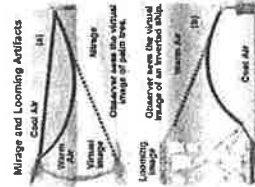


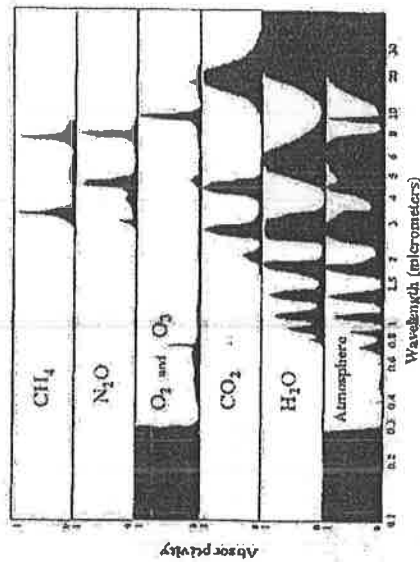
Figure 7

S. EM Spectrum & Reflection

1. Which of the following forms of radiation travels the fastest through a vacuum?

- A. Radio waves
 B. Microwaves
 C. Gamma rays
 D. None of these

The diagram to the right shows the photon absorption capabilities of various gases found in the atmosphere, depending on the wavelength of the photon radiation. Visible light is between 0.35 and 0.70 micrometers. The bottom graph shows the combined effects of all five gases. An absorption of 1 means 100%.



2. Which gas blocks (absorbs) the short wavelengths like UV?

- A. CH_4
 B. N_2O
 C. O_2 and O_3
 D. both A and B

3. Which gas blocks (absorbs) long wavelengths like infrared (heat)?

- A. H_2O
 B. CO_2
 C. O_2 and O_3
 D. both A and B

4. Which of the following is false about "sun tanning" under a glass cover?

- A. UV is transmitted by glass
 B. Radio waves are transmitted by glass
 C. Visible radiation is transmitted by glass
 D. Microwaves are transmitted by glass

5. Which of the following statements is false?

- A. All reflected light obeys the law of reflection
 B. Reflection causes polarization in light
 C. Specular surfaces collect light to a common focus
 D. All surfaces have a component of reflection

6. Two polarizing filters stacked and aligned so that they are both vertical. What portion of unpolarized light will pass through these filters?

- A. 0 %
 B. 25 %
 C. 50 %
 D. 100 %

7. Which of the following mirrors can produce a real image?

	Plane	Convex	Concave
A.	Yes	Yes	Yes
B.	Yes	Yes	No
C.	No	No	Yes
D.	No	Yes	No

8. A concave mirror has a focal length of 15 cm. What is its radius of curvature?

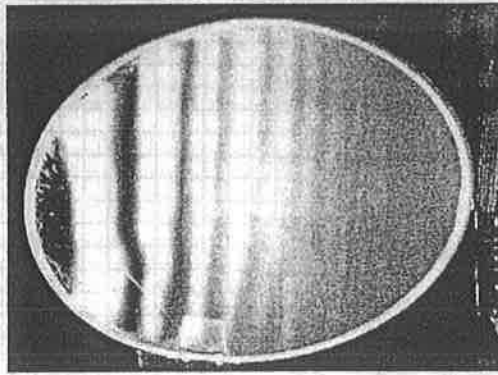
- A. 7.5 cm
B. 15 cm
C. 30 cm
D. none of the above

9. A pedestrian is walking directly towards the window of a building at a speed of 2 m/s. At what speed is the image approaching the pedestrian?

- A. 0 m/s
B. 2 m/s
C. 4 m/s
D. c

10. The image to the right shows a thin film of soap with (if you use your imagination) a cascading rainbow from top to bottom. What causes this effect?

- A. Reflection
B. Diffraction
C. Interference
D. Both A and C



T. Lenses & Dispersion

1. What causes white light to disperse into a colour spectrum?

- A. Interference
B. Refraction
C. Reflection
D. All of the above

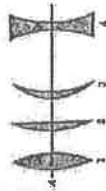


2. Which of the following phenomenon create "rainbows"?

	Refraction	Reflection	Dispersion
A.	Yes	Yes	Yes
B.	Yes	No	Yes
C.	Yes	No	No
D.	No	Yes	Yes

3. Which of the following is a double convex lens?

- A. 1
B. 2
C. 3
D. 4



4. Which of the following features is the primary focusing agent in mammalian eyes?

- A. cornea
B. lens
C. iris
D. pupil?

5. The image to the right shows a lens correcting a vision abnormality. What type of lens is being used, and what is the vision problem?



Lens	Vision Problem
A. converging	myopia
B. converging	hyperopia
C. diverging	myopia
D. diverging	hyperopia

6. The acetate roll on overhead projector is placed at a distance $1.2 f$ from the lens. (Where f is the focal length) At what distance should the screen be placed to properly focus the image?

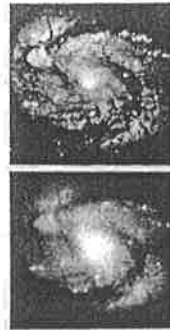
- A. $0.2 f$
B. $0.8 f$
C. $5 f$
D. $6 f$

7. An astronomer uses a converging lens with a focal length of 25 cm to observe a star. If the star is 1.5×10^{26} m away, what is the image distance?

- A. 0 m
B. 0.25 m
C. 0.24 m
D. 1.5×10^{26} m

8. Varying temperatures and moving air in the atmosphere causes visual distortions (shimmering) that limit the resolution and image quality of Earth based telescopes. What is this effect called?

- A. Black Body Radiation
B. Gravitational Lensing
C. Mirage
D. Seeing

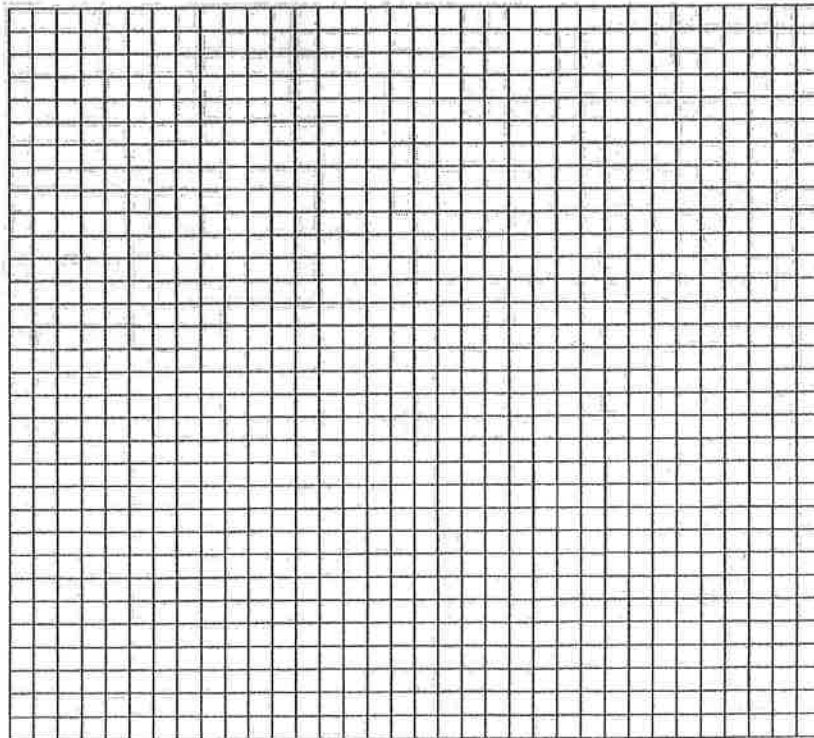


Earth based telescope vs. Hubble Space Telescope

Interpreting Graphical Information

Energy (Joules)	Speed (m/s)
0	0
5	1
18	2
41	3
72	4
110	5
162	6
224	7
290	8
360	9
450	10

- The following data table shows the kinetic energy measurements for various speeds of an unknown mass. Graphically determine the mass by following these steps:
- 1) Calculate and complete a third column labeled $\text{Speed}^2 \text{ (m}^2/\text{s}^2\text{)}$
 - 2) Graph Energy (Y) vs. $\text{Speed}^2 \text{ (X)}$
 - 3) Create a best fit line and measure the slope
 - 4) The slope represents $\frac{1}{2}$ the mass of the object in the experiment. Can you explain why?



ANSWER KEY:

Q:	1	2	3	4	5	6	7	8
A. MEASUREMENT	D	A	C	C	D	B	B	C
B. DISTANCE, SPEED, ACCELERATION	A	A	C	A	B	B	B	C
C. KINEMATICS OF UNIFORM ACC.	A	B	C	A	D	D	B	B
D. GRAPHING	D	D	B	C	B	C	B	B
E. DYNAMICS	C	C	A	A	D	D	D	C
F. FRICTION	D	D	D	B	A	D	C	A
G. HOOKE'S LAW + SPRING	A	D	C	A	C	D	B	C
H. UNIVERSAL GRAVITATION	D	B	D	D	B	A	D	C
I. MULTI-BODY PROBLEMS	A	C	C	D	C	B	0.09	C
J. MOMENTUM	B	D	C	A	B	A	B	B
K. WORK & ENERGY	A	D	A	D	C	B	C	C
L. PROPORTIONALITIES	C	A	A	B	C	A	A	A
M. POWER & EFFICIENCY	B	C	B	D	B	C	B	D
N. THERMODYNAMICS	A	D	D	A	D	B	C	B
O. SPECIAL RELATIVITY	A	D	C	D	B	C	B	B
P. NUCLEAR PHYSICS	B	A	C	C	B	B	A	D
Q. WAVE MECHANICS I	D	B	D	B	B	B	D	A
R. WAVE MECHANICS II	C	D	C	B	A	D	A	A
S. EM SPECTRUM + REFLECTION	P	C	A	B	A	C	C	C
SD. MIRRORS + REFRACTION	D	D	A	B	C	D	B	A
T. LENSES & DISPERSION	B	A	A	A	B	D	B	D

10
C D